FAA-STD-061
10/15/2003

DEPARTMENT OF TRANSPORTATION

FEDERAL AVIATION ADMINISTRATION

DESIGN STANDARD

AIRPORT FIBER OPTIC TRANSMISSION SYSTEM (FOTS)

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FOREWORD

This FAA document is approved for use by all organizations of the Federal Aviation Administration. (FAA). It establishes requirements for using fiber optic telecommunications systems and equipment in the National Airspace System (NAS) and references government and non-government standards, orders, handbooks, and other pertinent documents.

This standard provides information to assist NAS project personnel in acquiring and installing airport fiber optic systems and equipment. This information includes types of fiber optic equipment recommended, guidance on outside cable plant installation, remote maintenance and monitoring, installation planning considerations, project management, network architecture, program management, and life cycle support. The standard also provides general instructions for selecting and tailoring this standard for use in FAA acquisitions, procurements and evaluations, as well as sources for government and non-government documents.

This standard consolidates and revises information contained in FAA-STD-049, Fiber Optic Telecommunication Systems and Equipment, and FAA-STD-057, Fiber Optic Communications System (FOCS) Standard. This standard replaces and cancels FAA-STD-049 and FAA-STD-057.

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TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

LIST OF TABLES

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1. SCOPE

1.1 Scope. This document contains general information and guidelines for the design and implementation of fiber optics based communication systems at airports in the NAS. This standard establishes the minimum requirement when using fiber optic transmission systems (FOTS) and equipment to support air traffic control facilities in an airport or terminal environment. This document also addresses various stages in the implementation of fiber optic transmission systems including system design, site survey, integration, installation, test and measurement, training, and maintenance.

1.2 Purpose. This standard establishes the design criteria for fiber optic transmission systems (FOTS) used at airports in the NAS. This document provides building block information as well as an extensive list of technical documentation that may be used in selecting and procuring fiber optics systems and equipment. It provides guidelines that the FOTS project manager can follow in order to get to the desired airport fiber optics architecture in the most efficient manner. The ultimate goal of this standard is to develop a scalable and universally applicable architecture within the NAS that is reliable, maintainable, and at the best value.

1.3 Applicability. This standard applies to all fiber optic transmission systems and equipment designed, developed, procured, installed, operated, or maintained by or on behalf of the FAA to support air traffic control services at the airport and terminal environment with the exception of NAS systems deployed with an integrated fiber optic design. Supported applications include airport cable loops and point-to-point fiber optic links. Facilities installed prior to the approval of this document are not required to comply with this standard unless a determination is made that they don't meet the safety, security or supportability requirements of the NAS.

1.4 Classifications.

1.4.1 <u>Transmission Medium</u>. The primary transmission medium for Airport Fiber Optic Transmission Systems is fiber optic cables. The requirements section of this document identifies the various types of cables for various applications. Short runs of copper cable may be used to extend a communications interface to user equipment.

1.4.2 <u>Backbone Access Node (BAN)</u>. Backbone equipment consists of fiber optic multiplexers that are strategically interconnected and located throughout the airport to provide a survivable communications backbone. Backbone equipment is able to achieve this goal by taking advantage of diverse fiber cable installations and the use of self-mending communications protocol to automatically recover from catastrophic cable or equipment failures. Backbone equipment provides connectivity to Distribution Equipment or FAA equipment at or above the DS-1 rate.

1.4.3 <u>Distribution Equipment</u>. Distribution equipment provides the end-user interface to FAA equipment. Distribution equipment will be attached directly to the Backbone Equipment. Distribution equipment may be a channel bank, switch, logic controller, or router. Typical distribution equipment interfaces required at the airport are:

a. 4W Voice (VG-1/6/8)
b. 4W Voice E&M Signaling
c. 2W Voice
d. 2W FXS/FXO with Ring Generator
e. EIA-232
f. EIA-530/422
g. Ethernet
h. Contact Closure
i. V.35
j. DDS
k. EIA-485/422

Distribution equipment supporting the following interfaces may directly connect to the fiber optic cable:

a. Ethernet
b. Video Interfaces
    (1) CCTV – 6MHz (compressible)
    (2) ASDE – 50MHz
    (3) DBrite – 20MHz

1.4.4 Logic Controllers. Logic Controllers are used primarily to monitor the health of the Airport Fiber Optic Transmission System. Logic Controllers may also be used to control navigational aid (NAVAID) equipment.

1.4.5 Ancillary Equipment. Ancillary equipment includes the cables, demarc, connectors, adapters, patch panels, racks, and power supplies.

1.4.6 FOTS Network Monitoring System (NMS). The NMS is a centrally located computer system used to monitor and manage the Fiber Optic Transmission System.

2. APPLICABLE DOCUMENTS

2.1. Government Documents. The following documents provide detailed information on a number of subjects discussed or referenced in this standard. In the event of conflict between the requirements of this standard and those of the documents referenced herein, this standard shall have precedence over all referenced documents with the exception of FAA Orders. Refer to the most recent revision of the following documents.

2.1.1. Standards.

FAA-STD-019	Lightning Protection, Grounding, Bonding, and Shielding Requirements for Facilities and Equipment
FAA-STD-005	Preparation of Specifications, Standards, and Handbooks

2.1.2. Specifications.

FAA-C-1391	Installation and Splicing of Underground Cables
FAA-E-2761	Cable, Fiber Optic, Multi-mode, and Single-Mode, Multi-fiber
FAA-G-2100	Electronic Equipment, General Requirements
NAS-SR-1000	National Airspace System (NAS) System Requirements Specification

2.1.3. Other.

FAA Order 6000.36	Communications Diversity
FAA Order 6650.10	Maintenance of Fiber Optic Communications Equipment

2.2. Non-Government Documents. The following documents provide detailed information on subjects discussed or referenced in this standard. In the event of conflict between the requirements of this standard and those of the documents referenced herein, this standard shall have precedence. Where appropriate, existing FAA specifications and orders pertaining to the use of fiber optic systems and equipment shall have precedence over non-FAA documents.

2.2.1. ANSI/EIA/IEEE/IEC

TIA/EIA-232	Interface between Data Terminal Equipment and Data Circuit-Terminating Equipment Employing Serial Binary Data Interchange
TIA/EIA-422	Electrical Characteristics of Balanced Voltage Digital Interface Circuits
TIA/EIA-485	Electrical Characteristics of Generators and Receivers for Use in Balanced Digital Multipoint Systems
TIA/EIA-530	High-Speed 25-Posistion Interface for Data Terminal Equipment (DTE) and Data Circuit-Terminating Equipment (DCE)

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3. DEFINITIONS.

3.1 Transmission Equipment. Transmission equipment converts signal sources into a format compatible with the transport media. This equipment can be anything from a telephone handset, which converts audio to electrical, to a digital fiber optic multiplexer, which can accept electrical signals, combine them, and convert the resulting signal to light pulses.

3.2 Telephone Circuits. Standard phone lines (twisted pair copper) use an electrical analog signal in the voice frequency range (up to 4 kHz). Transmission equipment is a line card installed within the telephone switch at one end and the phone set or another telephone switch at the other end.

3.3 Channel Banks. Channel Banks are multiplexers designed for telephone circuit applications with inputs (channels) of either electrical voice signals or digital signals up to 64 kbps. The channel bank multiplexes 24 channels (along with control overhead) onto an electrical T-1 data stream (1.544 Mbps).

3.4 Digital Signal (DS) Multiplexers. Table 1 provides data rates for the DS hierarchy. There are a multitude of multiplexers on the commercial market that combine various low speed and high speed circuits. The most common configuration has a high speed side of DS-3 with the low speed side accepting a mix of circuits at DS-2 or lower.

Designation	Line Rate	Capacity
DS-0	64 Kb/s	Voice or data
DS-1	1.544 Mb/s	24 DS-0
DS-1C	3.152 Mb/s	2 DS-1
DS-2	6.312 Mb/s	4 DS-1
DS-3	44.736 Mb/s	28 DS-1
DS-4	274.176 Mb/s	168 DS-1

Table 1. Digital Signal (DS) Hierarchy

Physical interfaces for DS multiplexers come in a variety of mix-and-match configurations. The most common is a twisted-pair interface for DS-2 and below with a fiber optic interface for DS-3 and above. Higher speed interfaces may use coaxial cable. Regardless of media, transmit and receive require independent paths.

3.5 Synchronous Optical Network (SONET) Multiplexers. SONET refers to a hierarchical set of standards for high speed data transport utilizing fiber optic media. The SONET digital rates use the designation Optical Carrier. Table 2 provides the data rates for the Optical Carrier hierarchy. SONET is a US standard where Synchronous Digital Hierarchy (SDH) is the European standard. SONET was originally defined by Bellcore and later developed as an American National Standards Institute (ANSI) standard. SDH is the International Telecommunications Union (ITU) standard.

Electrical Designation	Optical Designation	European Designation	Line Rate
STS-1	OC-1		51.84 Mbps
STS-3	OC-3	SDH-1	155.52 Mbps
STS-9	OC-9		466.56 Mbps
STS-12	OC-12	SDH-4	622.08 Mbps
STS-18	OC-18		933.12 Mbps
STS-24	OC-24		1244.16 Mbps
STS-36	OC-36		1866.24 Mbps
STS-48	OC-48	SDH-16	2844.32 Mbps

Table 2. Optical Carrier (OC) Hierarchy

3.6 Asynchronous Transfer Mode (ATM). Asynchronous Transfer Mode (ATM) is a high-speed, connection-oriented switching and multiplexing technology that uses 53-byte cells (5-byte header, 48-byte payload) to transmit different types of traffic simultaneously, including voice, video, and data. ATM is a high-speed packet switching protocol that employs time-division multiplexing technology that does not dedicate time slots to specific transmission channels. It increases transmission efficiency by only transmitting data for active channels. ATM protocol is designed to operate over a wide range of data speeds. Data rates for ATM include: 1.544 Mbps (T-1), 25 Mbps, 44.734 Mbps (DS-3), 51.840 Mbps (SONET STS-1), 100 Mbps, 155.52 Mbps (SONET STS-3c), and 622.080 Mbps (SONET STS-12c). Potential physical media for ATM are those which can support these data rates, to include: coaxial cable, fiber-optic cable, voice-grade Category 3 and data-grade Category Five UTP.

3.7 Use of directive terms "shall", "must", "may", "should", and "will".

3.7.1 “Shall" is used, in the imperative form of the verb, exclusively in sections 4 and 5 of this standard to indicate a mandatory provision of this standard.
3.7.2. “Must" is used, in the declarative form of the verb, throughout this standard, to alert the reader to a mandatory provision directed by an FAA Order, directive, standard, or other authority. The basis and/or conditions of this authority are stated within the text or notes section.
3.7.3. “May" is used, in the imperative form of the verb, to describe an option within the context of a mandatory provision. It usually describes options in how to fulfill a requirement indicated by a "shall".
3.7.4. “Should" is used, to describe a recommendation.
3.7.5. “Will" is used to indicate intent.

3.8 Abbreviations and Acronyms

4-BLSR	4-fiber Bi-directional Line Switched Ring
4-BPSR	4-fiber Bidirectional Path Switched Ring
ACLS	Airport Cable Loop System

ALS	Approach lighting system
ALSF	Approach lighting system with sequenced flashers
AMP	Airport Master Plan
ANSI	American National Standard Institute
APS	Automatic Protection Switch
ASDE	Airport Surface Detection Equipment
ASR	Airport Surveillance Radar, also referred to as terminal radar (TRAD)
ATCT	Airport Traffic Control Tower
ATM	Asynchronous Transfer Mode
BRITE	Bright Radar Indicator Tower Equipment
COTS	Commercial Off-the-Shelf
CRC	Cyclic Redundancy Check
CSMA/CD	Carrier Sense Multiple Access/Collision Detection
DBRITE	Digital BRITE
DS	Digital Signal
EIA	Electronic Industries Association
E&M	Ear and Mouth
FAA	Federal Aviation Administration
FDDI	Fiber Distributed Data Interface
FDMA	Frequency Division Multiple Access
FFM	Far Field Monitor
FO	Fiber Optic
FOMAU	Fiber Optic Medium Attachment Unit (ANSI/IEEE 802.3)
FOTS	Fiber Optic Transmission System
FOTSM	Fiber Optic Transmission System Multiplexer
FS	Field Shelter
GDTS	Graphics-Based Display Terminal System
GS	Glide Slope
GOSIP	Government Open System Interconnection Profile
HVAC	Heating Ventilation Air Conditioning
I/O	Input/Output
IEEE	Institute of Electronics and Electrical Engineers
IOC	Integrated Optical Circuit
ILC	Injection Laser Diode
IM	Inner Marker
ISDN	Integrated Services Digital Networks
ISO	International Standards Organization
ITU-TSS	International Telecommunications Union-Telecommunications Standards Sector
LAN	Local Area Network
LED	Light-Emitting Diode
LIU	Line Interface Unit
LLC	Logical Link Control
LOC	Localizer
MALSR	Medium Intensity Approach Lighting System with Runway Indicator Lights
MAN	Metropolitan Area Network
MLS	Microwave Landing System

MM	Middle Marker
MPS	Maintenance Processor System
MULDEM	Multiplexer-Demultiplexer
NAILS	National Airspace Integrated Logistics Support
NAS	National Airspace System
NAVAIDS	Navigational Aids
NDI	Non-Developmental Item
NEC	National Electric Code
NFPA	National Fire Protection Association
NIMS	NAS Infrastructure Management System
NIST	National Institute of Standards and Technology
OM	Outer Marker
OSI	Open System Interconnection
PAPI	Precision Approach Path Indicator
PBLI	Product Baseline Index
PC	Physical Contact
PHY	Physical Layer, see OSI Protocol
PLC	Programmable Logic Controller
POF	Plastic Optical Fiber
RAIL	Runway Alignment Indicator Lights
RF	Radio Frequency
RMS	Remote Monitoring System
RMSI	Remote Monitoring System Interface
RVC	Radar Video Compression System
RR	Remote Receiver
RT	Remote Transmitter
RT/R	Remote Transmitter-Receiver
RVR	Runway Visual Range
RX	Receiver
SMO	Sector Management Office
SNMP	Simple Network Management Protocol
SONET	Synchronous Optical Network
SSC	System Support Center
STS	Synchronous Transport Signal
TIA	Telecommunications Industry Association
TML	Television Microwave Link
TRACON	Terminal Radar Approach Control
TRAD	Terminal Radar, a term used for terminal radar services such as ASR-7/8/9/11
TX	Transmitter
UPS	Uninterruptible Power Supply
VASI	Visual Approach Slope Indicator
VF	Voice Frequency
WAN	Wide Area Network
XCVR	Transceiver

4. GENERAL REQUIREMENTS.

4.1 Airport Cable Loop System (ACLS)/Fiber Optic Transmission System (FOTS). The ACLS is a system of cables, communications, monitoring, and auxiliary equipment designed to provide a survivable communications infrastructure for critical services and facilities at airports. FOTS is an ACLS implementation using fiber optic cables as the primary transmission medium. Figure 1 depicts a typical fiber optics cable layout at an airport with only one runway depicted.

4.2 Airport FOTS Configurations. A single fiber loop network cannot support FOTS critical services over an entire airport. Due to the critical nature of the services at an airport, the creation of one single network for the entire airport is prohibited. In the target architecture, the runway navigational aids (NAVAIDS) facilities will be on a loop configuration. The NAVAIDS equipment in these facilities terminates to equipment at the Airport Traffic Control Tower (ATCT). At airports with multiple runways, it is preferable to isolate the networks for each runway. The Remote Transmitter-Receiver (RT/R) and Airport Surveillance Radar (ASR) facilities will have dedicated redundant fiber connections to the ATCT. If needed, a separate fiber loop may be installed within the ATCT. Depending on local needs, the ATCT loop may be designed to incorporate the TRACON and other neighboring facilities. The addition of Navaids to FOTS requires completion of the Navaids configuration control process. The airport fiber configurations are as follows:

a. Runway
b. RT/R
c. ASR
d. ATCT/TRACON

4.3 Design Criteria. The Airport FOTS design must satisfy all the requirements for various types of interfaces required at the airport and should take advantage of current technology to ensure the system provides continuous and reliable service.

4.3.1 Runway Fiber Loop. The target architecture for Airport FOTS fiber loop is a SONET 4-fiber Bidirectional Path Switched Ring (4-BPSR) or 4-fiber Bi-directional Line Switched Ring (4-BLSR). The SONET equipment must use universal optical transmission standards and protocols to allow interconnection with different models of equipment. It must employ an intelligent protocol that automatically detects line or equipment failures, and automatically re-route connections without human intervention. The system must provide a means for local Airway Facilities (AF) personnel to view the status and alarms on the system, and to facilitate the restoration of services. See Figure 2 for the target implementation of a SONET runway loop.

4.3.2 Interim Runway Solution. This solution employs fiber optic transducers (i.e., DS-1 to Optical T-1) or multiplexers (see figure 3). The transducer or multiplexer provides DS-1 to the distribution equipment, which is commonly a channel bank. The primary drawback to this method is the high number of fibers. Whereas a SONET 4-BPSR or 4-BLSR ring topology can support as many as 5 nodes with just 4 fibers, the interim runway solution with 5 nodes will require 8 fibers. With each additional node, an additional pair of fibers will be required only for the interim solution. Moreover, the use of dedicated equipment between the ATCT and each remote site will result in a corresponding increase in equipment at the Control Tower. Program management support for this solution exists only as long as logistics support is available for the equipment. Refer to the current FOTS Product Baseline Index (PBLI) for a list of supported equipment. The PBLI is available from the ACLS/FOTS Program Manager.

4.3.3 RT/R and ASR. Due to the criticality of the RT/R and ASR services, dual equipment and fiber backbones shall be installed at a minimum, (see figures 4 and 5). The fiber multiplexer shall support DS-1, DS-3, OC-1, or OC-3. The multiplexer electrical interface provides a DS-1 signal to a channel bank, which in turn provides voice or data interface for distribution. In the ASR configuration, a switch is added to ensure survivability of service even with catastrophic failure of one path. A switch is not used in the RT/R configuration because the design takes advantage of the switching capability within the Voice Switch. Survivability of the RT/R configuration is further ensured through the segregation of the MAIN and STANDBY radios using separate redundant fiber networks. RT/R and ASR services may also be implemented in a 4-fiber Bidirectional Path Switched Ring (4-BPSR) or 4-fiber Bi-directional Line Switched Ring (4-BLSR) SONET ring architecture. In the instance that the RT/R and ASR are collocated, it is permissible to combine both services in a 4-BPSR or 4-BLSR SONET loop. To maintain segregation of the MAIN and STANDBY radios and redundancy for the ASR, dual SONET multiplexers will also be required for the RT/R and ASR collocated configuration.

4.3.4 ATCT/TRACON. This standard applies to fiber routes transmitting NAS services vertically between the ATCT base building and cab equipment room or between the ATCT and TRACON on the same airfield. See figure 6.

4.4. Outside Cable Plant. FAA Specification FAA-E-2761 provides requirements for selection and splicing of fiber optic cables.

4.5 Transmission Equipment. An FAA specification will be created for each type of FOTS transmission equipment. Equipment meeting the specifications will be qualified and selected. Support will be established for this equipment, and it will become part of the current FOTS Product Baseline Index (PBLI). An FAA Type number will be issued for approved equipment. The ACLS/FOTS program office will establish and maintain the FOTS PBLI.

4.5.1 Synchronous Optical Network (SONET) Multiplexers. The target airport backbone consists of SONET transmission equipment operating over single-mode fiber optic cable. The SONET multiplexers will provide an interface to the distribution equipment and end-user traffic at the DS-1 rate and above. ATM cells and traditional TDM circuits will be mapped into the SONET payload for transmission. All traffic on SONET backbone links should be aggregated to a minimum OC-1. The target architecture will also support OC-3 fiber multiplexers. The SONET multiplexer must meet switching time requirements for all services. Refer to the Product Baseline Index (PBLI) for a list of supported SONET multiplexers.

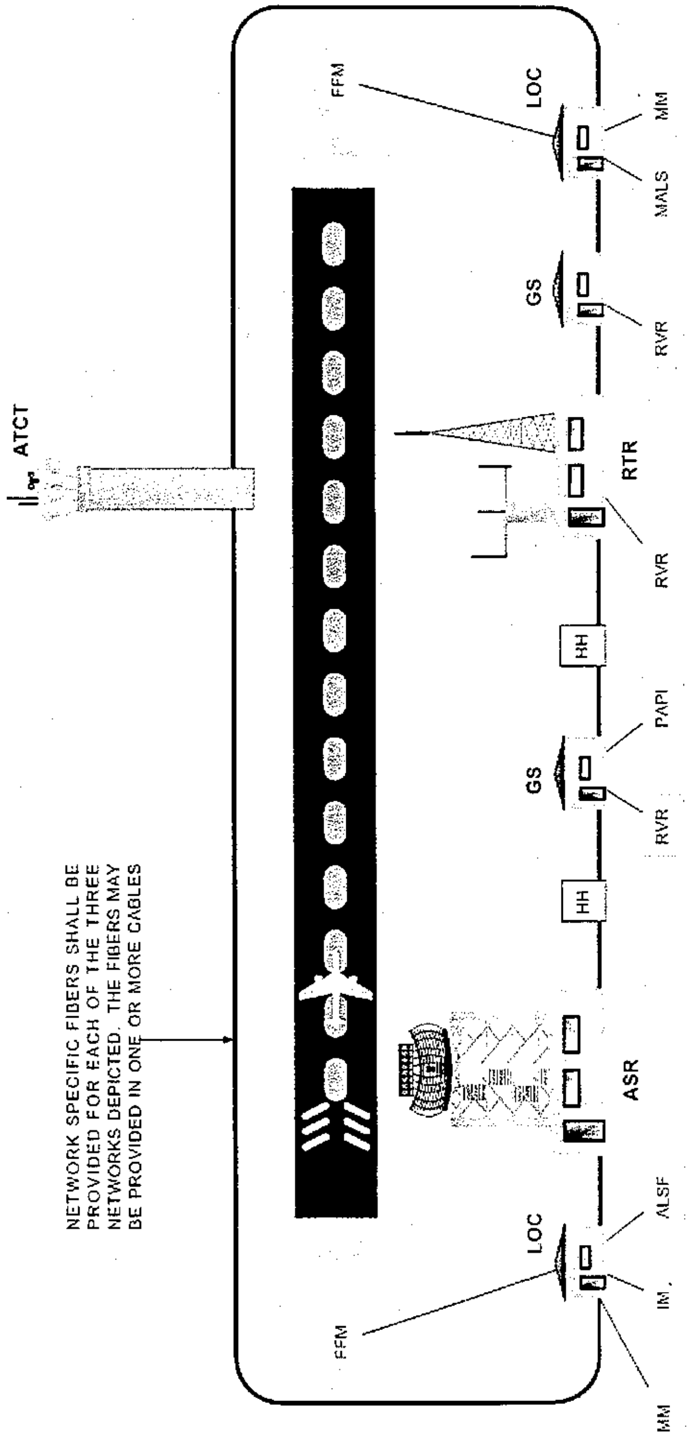

Figure 1. Representative Airport Cable Loop Diagram

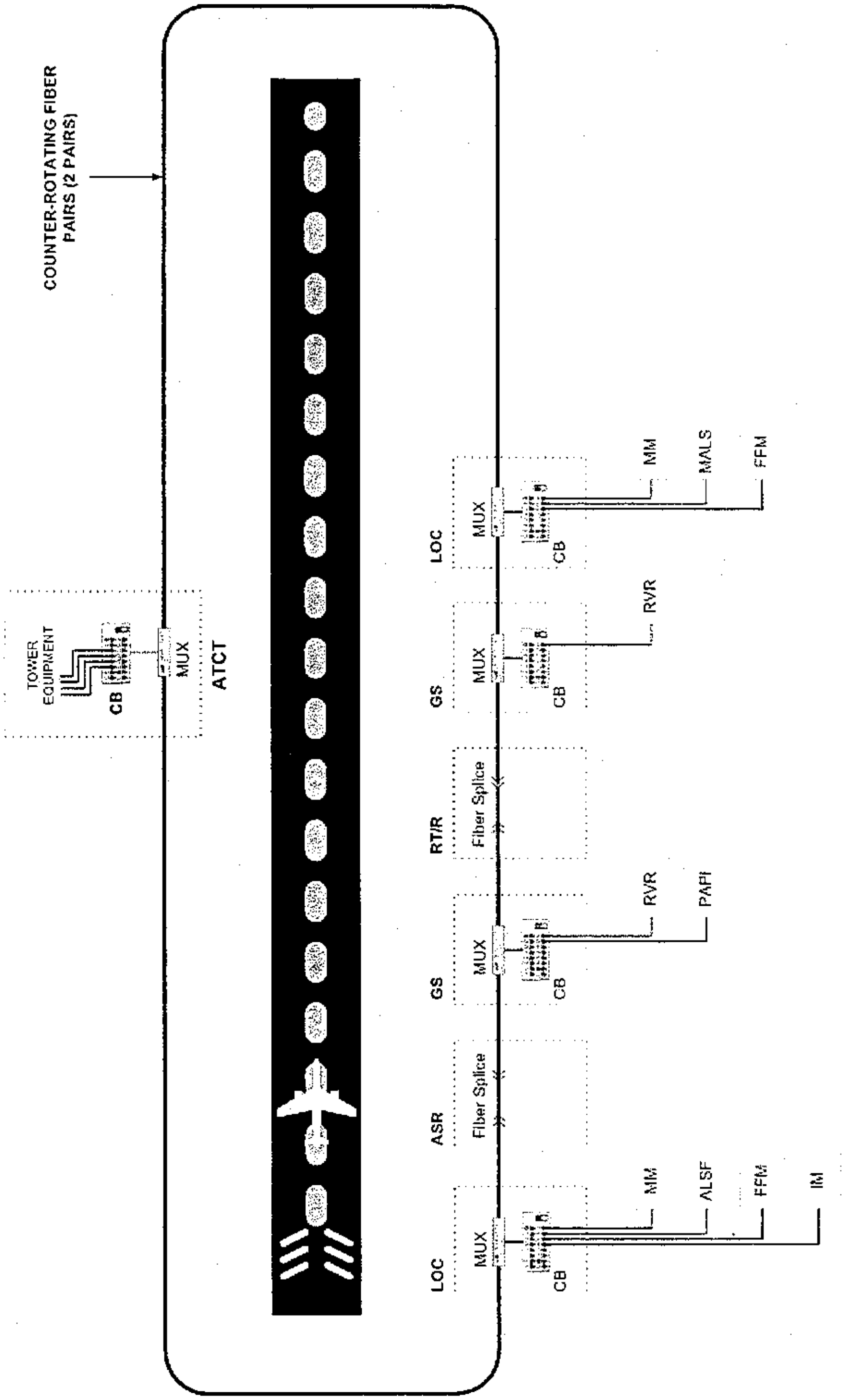

Figure 2. SONET Runway Loop Configuration

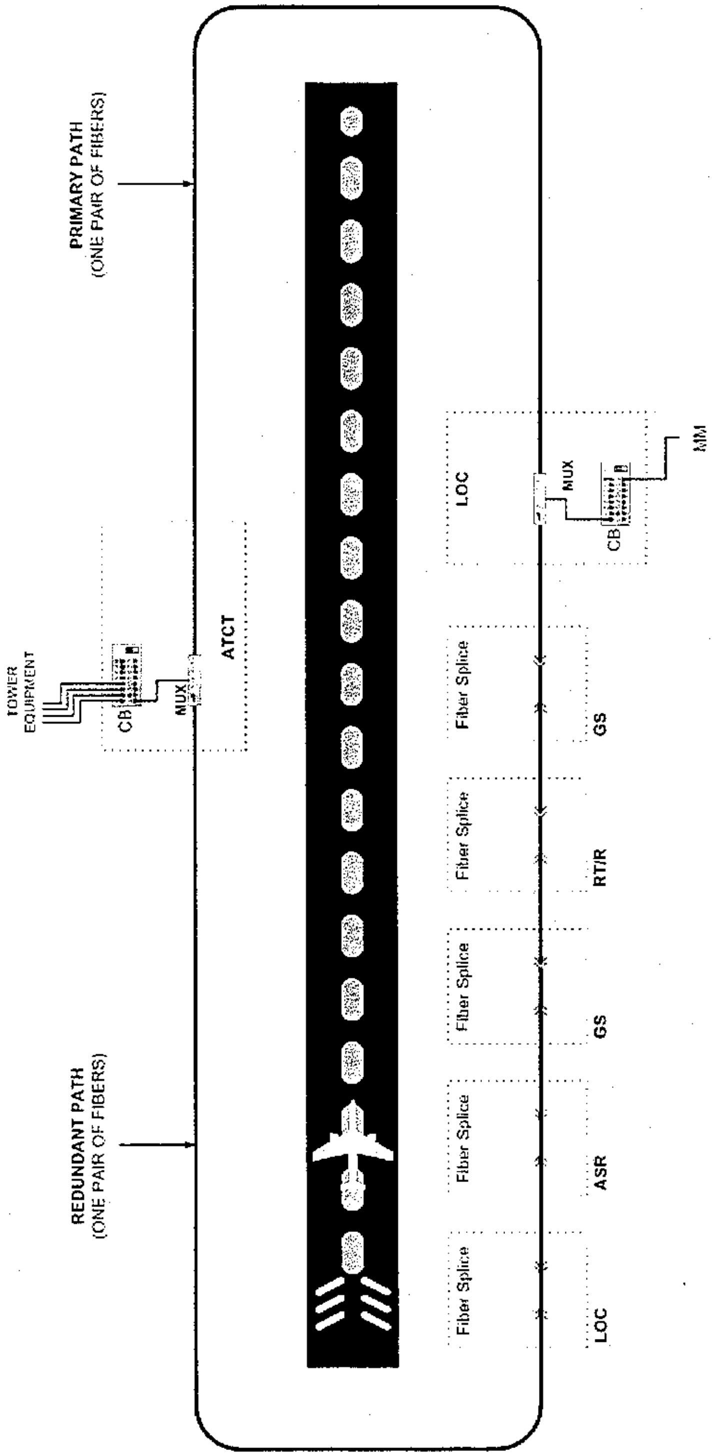

Figure 3. Interim Runway Configuration (One Remote Site Shown)

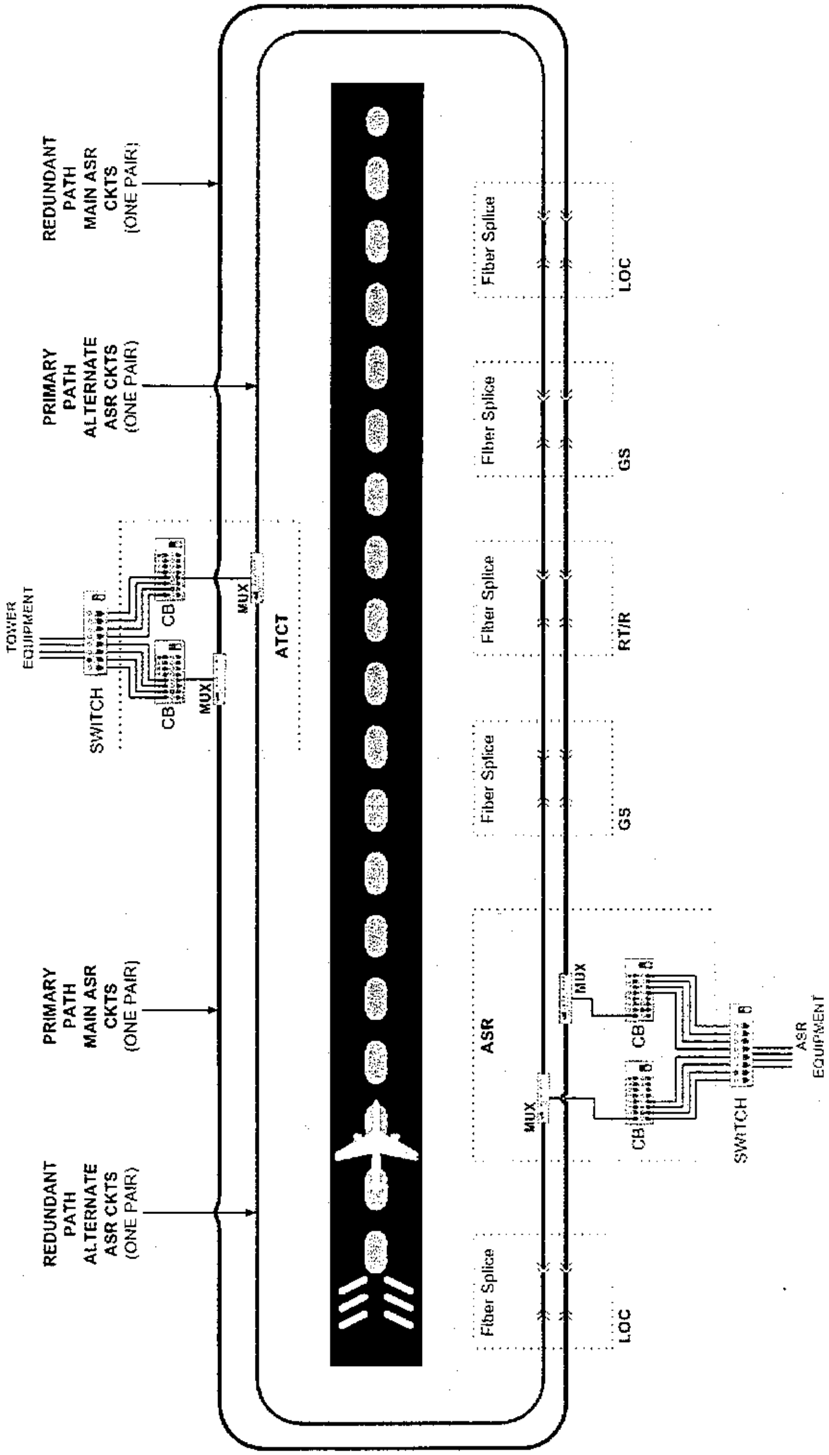

Figure 4. ASR Configuration

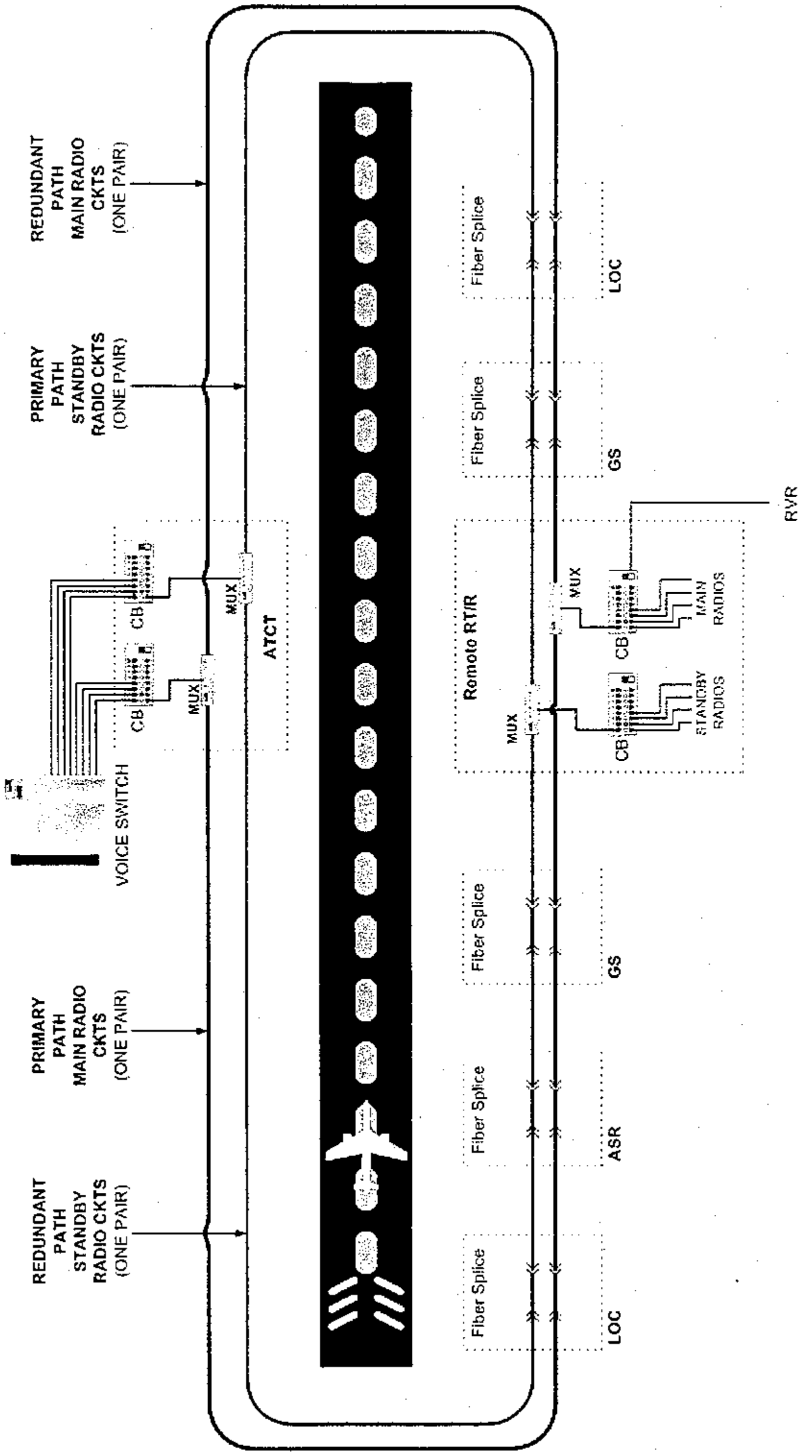

Figure 5. RT/R Configuration

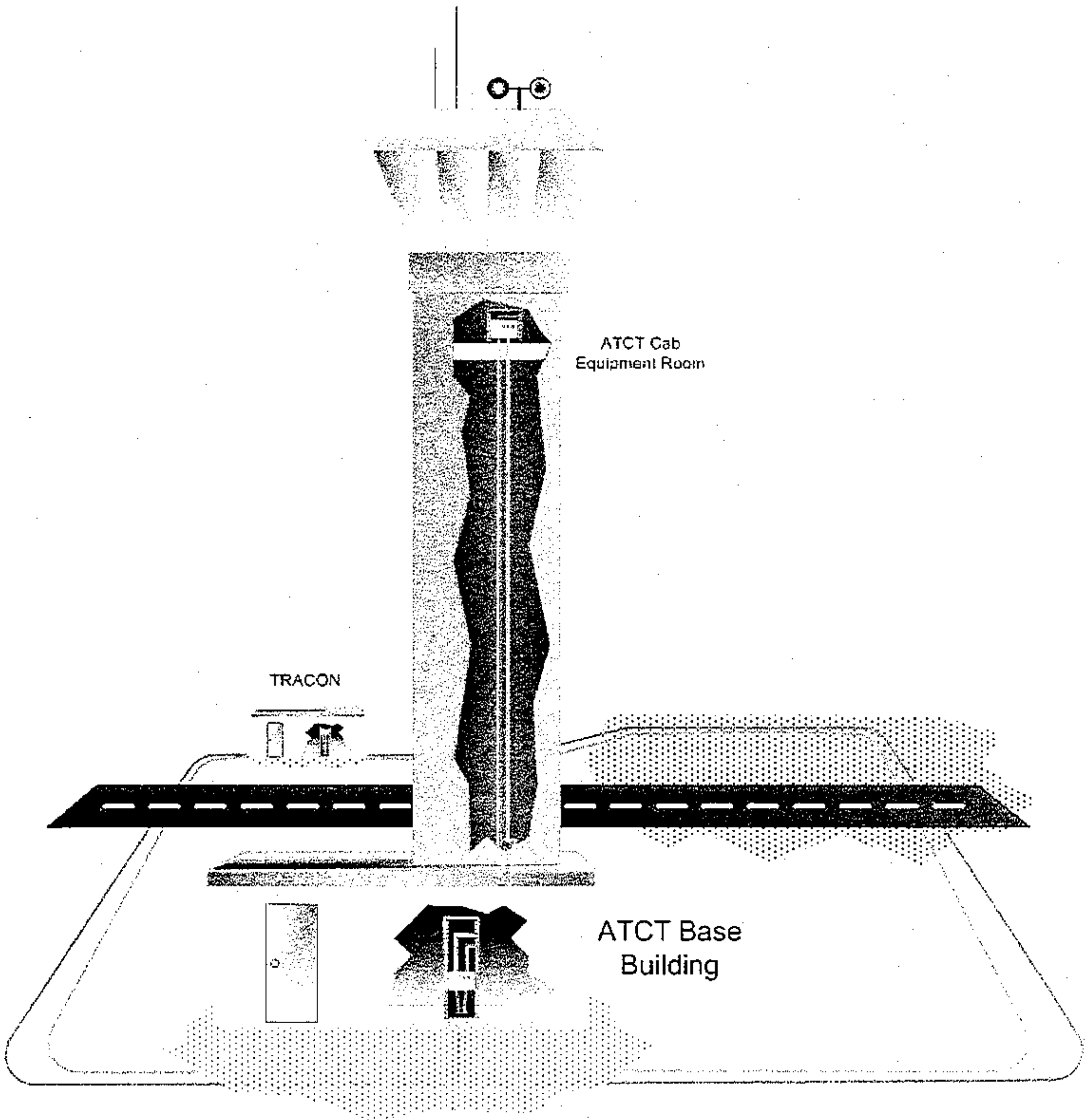

Figure 6. ATCT/TRACON Configuration

4.5.2 Channel Banks. Channel banks will be used as distribution equipment to provide low-speed data and audio interfaces.

4.5.3 Miscellaneous Transmission Equipment. Point-to-point transmission equipment may be required to provide interfaces not readily adaptable to DS-1 or SONET multiplexers. Examples of these interfaces include high speed Ethernet and non-compressible video.

4.6 FOTS Network Monitoring System (NMS). A FOTS NMS should be installed to provide local AF personnel with the capability to monitor the status of the FOTS system and equipment. A NMS must be installed when operational status of the FOTS is required to support operations. If a network monitoring system is installed it must be capable of detecting major failures in the network. An equipment or system failure is categorized as MAJOR when it potentially results in a service outage or in loss of redundancy for critical services. The NMS should be able to diagnose the failure to the affected equipment shelf. The NMS should also be able to perform the following:

a. Depict a pictorial representation of the network.
b. Display System status and alarms.
c. Identify equipment shelf at fault.
d. Identify loss of facility power.
e. Provide visual and audible alarm.

4.6.1 Communications Equipment. FOTS backbone and distribution equipment may provide an interface to the NMS in order for the NMS to perform the tasks listed above. At a minimum, the equipment must be equipped with a contact closure output that will indicate a major equipment alarm, (i.e., Loss of Signal, Clock Failure). The ability to indicate other alarms such as Remote Alarm or Component Failure is desired. Serial data interface or equipment-specific network monitoring may be used instead of the contact closure output for reporting status and alarms. Depending on compatibility with the NMS protocol, a proxy agent may be required to interface other types of monitoring systems to the NMS equipment.

4.6.2 NMS Effect on the Network. The NMS must be transparent to the network. A failure of the NMS or any component of the NMS shall not affect the operation of the Airport FOTS system.

4.7 Logic Controllers.

4.7.1 Programmable Logic Controllers (PLC). PLCs are used primarily to monitor the health of the Airport Fiber Optic Transmission System. They may also be used to pass discrete control and sensory signals between various airport facilities and the ATCT/TRACON.

4.7.1.1 Interface Requirements. PLC's are used to detect changes in equipment or facility status by sensing contact closures, changes in current draw, or variations in input voltage levels. Upon detection of a change in input, the PLC can be programmed to respond with corresponding contact closure, changes to output voltage or current, or provide monitoring status to the NMS.

When used in any application, the PLC interface component must be rated to accommodate the voltage and current load rating of the equipment being monitored or controlled.

4.7.1.2 Communications Requirements. When used as a remote sensor for reporting status of equipment or facility, the PLC must be able to report the status to a central location. When used to pass discrete controls, the PLC must also be able to provide confirmation after a control command is performed. To accomplish these tasks, the PLC must be equipped with a means to communicate with a central monitoring system that is readily accessible and observable by the AF maintenance workforce. The FOTS NMS may also be used as the central PLC monitoring system. In this situation, the PLC must have a communications interface and protocol that is compatible with the NMS.

4.8 Planning Considerations

4.8.1 Bandwidth. For practical purposes, the speed or bandwidth capacity of one strand of single-mode fiber optic cable is limited only by the electronics attached to each end of the glass fiber. When using digital service (DS) multiplexers, the typical data rate is DS-1 (1.544 Mbps) or DS-3 (44.73 Mbps). Multiplexers employing SONET technology communicate at Optical Carrier (OC) rate of OC-1 (51.84 Mbps) or OC-3 (155.52 Mbps). Higher rates are common in the telecommunications industry, where high capacity trunks may run at a rate of OC-192 (9,953 Mbps) on a single fiber.

When designing any fiber project, determine present and future bandwidth requirements. Try to identify any airport systems that are slated for upgrade or replacement within the next 5 to 10 years. If possible, anticipate any changes in bandwidth requirement for these systems, and include the value in the overall calculation. Use good engineering judgment in deciding between additional bandwidth cost versus the risk of having to re-design the backbone in the future.

4.8.2 Space. Reserve space for the new equipment. In most airport installations, the old cable loop system will need to remain operational while the new system is being installed and tested. Reserve enough space for racks (if any), power supplies, redundant equipment, wall space, cable bridge, and room for the installation team and their equipment.

4.8.3 Power. Primary and backup power requirements for FOTS equipment shall be the same as the type of facility being serviced. Where backup power is required, use of an emergency engine generator or an uninterruptible power supply (UPS) is recommended. For RT/R and ASR facilities, redundant power supplies shall be provided for the main and standby equipment. When possible FOTS equipment shall have at least one power supply fed by a critical power bus or DC power system when available.

4.8.4 Heating, Ventilation, and Air Conditioning (HVAC). HVAC requirements for FOTS equipment shall meet or exceed the requirements of the facility in which it is installed. FAA-G-2100 identifies facilities as manned controlled, unmanned controlled, unmanned uncontrolled, etc. Refer to FAA-G-2100 for specific HVAC requirements.

4.9 Network Architecture.

4.9.1 Communications Diversity. FAA Order 6000.36 governs the communication diversity requirements for FAA services. Consult this directive for specific guidelines for reducing the vulnerability of critical services from single points of failure.

4.9.2 Availability Requirements. Based on NAS-SR-1000, NAS System Requirements Specifications, the required availability and restoration time for the three levels of services are listed in table 3.

Level	Availability	Restoration Time
Critical	.99999	6 seconds
Essential	.999	10 minutes
Routine	.99	1.68 hours

Table 3. Availability and Restoration Requirements

Critical – Functions or services, which if lost, would PREVENT the NAS from exercising safe separation and control over aircraft.

Essential – Functions or services, which if lost, would REDUCE the capability of the NAS from exercising safe separation and control over aircraft.

Routine – Functions or services, which if lost, would NOT SIGNIFICANTLY DEGRADE the NAS from exercising safe separation and control over aircraft.

Stated availability requirements are for end-to-end performance of the covered functions or services. The airport FOTS equipment shall not cause end-to-end performance to drop below these availability requirements.

4.10 Communications Requirements. FOTS architecture must meet the communications requirements of the services that utilize the system. FAA Order 6000.36 identifies communications diversity requirements for FAA services. The FOTS architecture and components may be required to have diverse paths to support the service requirements. Navaid services also may require diversity for higher category operations. Additional requirements for communications may be identified for FOTS to the ATCT or TRACON.

4.10.1 Communications Robustness. Four levels of communications robustness are identified to support communications requirements for FOTS. These levels are identified within Table 4 below.

Level	Availability	Continuity (MTBO)	Redundancy	Reporting
Critical	.99999	100,000 hours	Diverse fiber and connectivity	Degraded Modes
Severe	.9999	10,000 hours	Diverse fiber	Degraded Mode
Essential	.999	1,000 hours	N/A	N/A
Routine	.99	100 hours	N/A	N/A

Table 4. Communications Robustness

Critical – Functions or services, which if lost, would PREVENT the NAS from exercising safe separation and control over aircraft, or a navigation failure that create an unsafe operating condition.

Severe – Functions or services, which if lost, would SEVERELY, degrade the capability of the NAS from supporting safe operations.

Essential – Functions or services, which if lost, would REDUCE the capability of the NAS from exercising safe separation and control over aircraft.

Routine – Functions or services, which if lost, would NOT SIGNIFICANTLY, DEGRADE the NAS from exercising safe separation and control over aircraft.

Communications requirements are for end-to-end performance of the covered functions or services. Availability is stated in terms of operational availability objectives. Continuity is stated in terms of the mean-time-between-outage (MTBO) caused by a failure of communications. Redundancy requirements are stated in terms of the level of redundancy required to support these types of services. Reporting requirements are stated where the loss of redundancy must be identified operationally. The airport FOTS equipment shall not cause end-to-end performance of any communications link to drop below the specified communications requirements.

5. DETAILED REQUIREMENTS

5.1 Airport Facilities and Services. Typical facilities at an airport are Air Traffic Control Tower, TRACON, air-to-ground radio sites, navigational aids, and terminal radar. Typical airport loop connectivity requirements for airport facilities are listed in table 5. Typical connectivity ATCT connectivity requirements are listed in table 6.

Detailed requirements are located within TI Manual for the equipment. Note that an NCP may be required to obtain approval for interconnection.

SERVICE	BASIC REQUIREMENT
Airport Surface Detection Equipment X (ASDE-X)	Data (DDS)/V.35
Airport Surface Detection Equipment 3 (ASDE-3)	RS-232
Airport Surveillance Radar (ASR/RVCS 2000)	Data/Analog /Video
Approach Lighting System (ALS/ALSF)	2W Analog/Contact Closure
Digital BRITE (DBRITE)	Data/Video
Distance Measuring Equipment (DME)	2W Analog/Contact Closure
Doppler VHF Omni-directional Range (VOR)	4W (Data)/ 2W POTS (Maint) Analog
Far Field Monitor (FFM)	2W Analog
Glide Slope (GS)	2W Analog/Contact Closure
Inner Marker (IM)	2W Analog/Contact Closure
Local Area Network (LAN)	Data (Ethernet)
Localizer (LOC)	2W Analog/Contact Closure
Medium Intensity Approach Lighting System with Runway Indicator Lights (MALSR)	2W Analog/Contact Closure
Microwave Landing System (MLS)	2W Analog
Middle Marker (MM)	2W Analog/Contact Closure
Outer Marker (OM)	2W Analog/Contact Closure
Precision Approach Path Indicator (PAPI)	RS-232(RMM)/2W Analog/ Contact Closure
Remote Maintenance and Monitor (RMM)	Data (DDC)/RS-232/2W Analog
Remote Transmitter-Receiver (RT/R)	4W E&M Analog/Contact Closure
Runway Alignment Indicator Lights (RAIL)	2W Analog/Contact Closure
Runway End Identification Lights (REIL)	2W Analog/Contact Closure
Runway Visual Range (RVR) / RLIM	2W Analog
Visual Approach Slope Indicator (VASI)	2W Analog/Contact Closure
Wide Area Network (WAN)	Data (DS1, DDC)

Table 5. Airport Facilities and Services

SERVICE	BASIC REQUIREMENT
Airport Surface Detection Equipment X (ASDE-X)	Data (DDS)/V.35
Airport Surface Detection Equipment 3 (ASDE-3)	RS-232
Airport Surveillance Radar (ASR/RVCS 2000)	Data/Analog /Video
Approach Lighting System (ALS/ALSF)	2W Analog/Contact Closure
Digital BRITE (DBRITE)	Data/Video
ILS supporting Category II/III operations	NCP required
RVR supporting Category II/III operations	NCP required
Remote Transmitter-Receiver (RT/R)	4W E&M Analog/Contact Closure

Table 6. ATCT Services

5.2 Outside Cable Plant. FAA Specification FAA-E-2761 provides guidelines for the selection and installation of fiber optic cables.

5.2.1 Backbone Cabling. Airport backbone cabling shall be single-mode only. When a separate requirement for multi-mode fibers exists, install single-mode with the multi-mode cable. In this instance, the use of hybrid cable is recommended. For ATCT, TRACON, and large facilities, installation of both fiber types are recommended.

5.2.2 Cable Terminations. Terminate fiber cables in wall-mounted or rack-mounted patch panels utilizing PC polished, heat-cured epoxy ST fiber connectors with zirconia, ceramic, or silicon carbide ferrules. Secure loose cables so that they are not susceptible to damage. When connecting the patch panel to equipment or to another patch panel, only use jumper cables with the same core diameter as the outside fiber cable, (i.e. 9 to 9 microns, 50 to 50 microns, 62.5 to 62.5 microns, etc.)

5.2.3 Manholes and Ducts. Underground manhole and duct systems should be used. Cable runs between nodes should be installed in manhole and duct systems to increase protection. Exceptions may only apply where environmental limitations or construction costs dictate other solutions.

5.2.4 Fiber Splices. All splices shall be accomplished using the fusion splice method. Fusion splices must not exceed 0.2 dB loss. Secure fusion splices with protective sleeves and splice trays. Mechanical splices may only be used in emergency situations, and will not be permanent. For underground splices, protect splices by using a waterproof enclosure and encapsulant.

5.2.5 Marking. Mark buried cables on the surface according to FAA-C-1391. All fiber optic cable routes not including copper cable should be installed with resonant markers or locating wires to facilitate the identification of the duct. The use of laminated ribbon is not recommended because it is easily damaged and difficult to splice. A 14 AWG insulated tracer wire or resonant markers in compliance with FAA-STD-19 (available from commercial manufacturers) may be used instead.

5.2.6 Grounding Requirements. In most applications all-dielectric cables will be used. If outside plant cables containing metal shielding or metal strength members are used, the metal shield or strength member must be grounded at building entrance locations. This will prevent stray currents from lightning strikes or transients from contact with power cables from damaging equipment or harming personnel. Bonding between communications and power grounds is addressed in FAA-STD-019 and the National Electric Code (NEC), Article 800-40(d). Telecommunications system grounding requirements are specified in the National Electric Code (NEC), Articles 250-21, 250-83, 250-84, and 250-91.

5.3 Network Architecture.

5.3.1 Criticality Levels of Airport FOTS Services. Based on the definition of critical levels in NAS-SR-1000, and the list of critical systems in Order 6000.36, the critical levels of airport services are listed in table 7.

Airport Services	Criticality
Terminal Radar (ASR-7/8/9/11) to TRACON	Critical, Priority 1
Terminal Radar (ASR-7/8/9/11) to ATCT	Critical, Priority 2
Receiver/Transmitter (RT/R) to ATCT/TRACON	Critical, Priority 1
ILS, RVR, ALSF supporting Category II/III operations to ATCT Navigational Aids (ILS, VOR, MALSR, etc.)	Critical
ILS LOC, GS, Marker Beacons, RVR, ALSF supporting Category II/III operations – per runway loop	Severe
Visual Aids (PAPI, VASI, etc.)	Essential
Navigational Aids (ILS, VOR, MALSR, etc.) Supporting Category 1 or lesser operations- per runway loop.	Essential
DBRITE (Video and Control)	Essential
Administrative LAN, Telephone, RMM	Routine

Table 7. Criticality Levels of Airport Services

5.3.2 Redundancy. Any system that relies on a single interface will always have a single point of failure. Hence, the tradeoff on where to place the single point of failure requires a good knowledge of the operation of the system and sound engineering judgment. This decision is based on the inherent capability of the communications system as compared to the increased cost due to additional equipment and connectivity. Because of the criticality of the ASR and the RT/R systems, a redundant FOTS backbone will be implemented for these systems.

5.3.3 FOTS Equipment. Airport FOTS equipment providing connectivity to critical services must be equipped with redundant common modules. Standby modules must automatically take over the function upon failure of the primary component. In addition, the equipment must be capable of reporting alarms and failures to the FOTS network monitoring system (NMS) to advise maintenance personnel of degraded operation or outage. Common modules may include optical cards, processors, power supplies, memory cards, clock modules, and bus cards. Note that equipment reliability must support the service criticality requirements. This may impose a higher mean-time-between-failure (MTBF) on single equipment types than the MTBO of the service, unless redundancy reduces the MTBF requirement. Where redundancy is used, however, the continuity requirements need to be sustained.

5.3.4 Communications Path. Airport FOTS equipment on the SONET loop will be inter-connected using the 4-BPSR or 4-BLSR architecture. The architecture should automatically detect transmission errors and path failures, and be self-healing. FOTS equipment interfaced to the fiber loop must report alarms to the NMS to advise maintenance personnel of degraded operation or outage.

5.3.5 Service Interfaces. For added availability, redundancy may be implemented for voice (i.e., VG-1/6/8) and data interfaces, (i.e., EIA-232/EIA-530/V.35). If redundancy is required for a service, voice grade interfaces shall be switched using switches that detect loss of carrier signal, and digital data services shall be switched using switches that detect loss of data carrier detect (DCD) signal. These automatic sensing switches shall provide switching that meets restoration time requirements for that service and is synchronized for each end of the switched circuit. This will prevent unscheduled outages caused by chattering switch contact.

5.3.6 Implementation. Airport FOTS installations shall be implemented using equipment found in the Product Baseline Index (PBLI).

5.3.7 Migration. Airports are encouraged to migrate to the target architecture on the first opportunity of an airport cable loop upgrade.

6. NOTES

6.1 Quality Control Provisions. All tests shall be performed by the implementation organization. If the implementation is accomplished by non-FAA organization, the tests shall be witnessed by the FAA. If FAA witnessing is waived, the implementation team shall provide certified test data.

6.1.1 Cable Testing. Cable testing will be performed in accordance with applicable FAA standards and directives, (i.e., FAA-E-2761 and Order 6650.10).

6.1.2 Equipment Testing. Functional and operational testing will be conducted in accordance with Order 6650.10, Maintenance of Fiber Optic Communications Equipment. When required, test plans and procedures will be developed in accordance with FAA-STD-024, Preparation of Test and Evaluation Documents.

6.2 Tailoring.

6.2.1 General. Tailoring is the process of selecting appropriate portions of the standard for citation on other documents, (e.g., acquisition documents, specifications, statement of work). Tailoring may occur at the major section, subsection, or paragraph level, and may consist of adoption, elimination, modification, or substitution of requirements.

6.2.2 Citing This Standard. This Standard for Airport Fiber Optic Transmission Systems may be cited in its entirety if communications interfaces are not known in advance, or have yet to be determined through system planning, engineering, and analysis. Citing the standard in its entirety does not restrain the contractor from requesting tailoring later in the program.

6.2.3 Deviations from This Standard. The contractor may request or recommend tailoring at any time during acquisition, update, or modification of contracts, or during advanced development or research contracts. The contractor may also request waivers and offer alternatives for the applicable design criteria and guidelines, respectively.

6.2.4 Non-Developmental Items (NDI) and Commercial Off-The-Shelf (COTS). For COTS and NDI items, the FAA may provide a tailored checklist to the contractor, who will in turn submit equipment bids or use the tailored checklist as part of an equipment selection process.

6.2.5 Authority to Tailor. Tailoring may be performed by the FAA only, or by a selected contractor performing the tailoring under the supervision of the FAA.

6.3 Additional Documents.

6.3.1 Government Documents. The following documents provide detailed information on a number of subjects discussed in this standard.

6.3.1.1 Standards.

FAA-STD-013	Quality Control Program Requirements
FAA-STD-024	Preparation of Test and Evaluation Documents
FED-STD-1037	Telecommunications: Glossary of Telecommunications Terms
FIPS-PUB 146-1	Government Open Systems Interconnection Profile (GOSIP)

6.3.1.2 Specifications.

NAS-SS-1000	National Airspace System (NAS) System Specification
FAA-TN91/9	Glossary of Optical Communications Terms (DOT/FAA/CT-TN91/9)
FAA-E-2788	EIA-232 Transceiver, Fiber Optic
FAA-E-2789	Controller, Programmable, Monitor and Control
FAA-E-2790	Airport Surveillance Radar Transmission System, Video Fiber Optic
FAA-E-2809	Manufacturing Specifications for Interface Modules and Boards, Fiber Optic Communications, Airport Facility
FAA-E-2810	T-Carrier with Drop-and-Insert, Fiber Optic
FAA-E-2820	Multiplexer-Demultiplexer (MULDEM) Optical Transceiver, Drop-Insert
FAA-E-2911	National Airspace System (NAS) Infrastructure Management System (NIMS) Managed Subsystems

6.3.1.3 Other.

FAA Order 1830.7	Fiber Optic Transmission Systems and Equipment Policy
FAA Order 6000.15	General Maintenance Handbook for Airway Facilities
FAA Order 6000.22	Maintenance Handbook for Analog Circuits
FAA Order 6000.30	National Airspace Maintenance Policy
FAA Order 6000.47	Maintenance Handbook for Digital Circuits
FAA Order 6032.1	Modification to Ground Facilities, Systems, and Equipment in the NAS
FAA Order 6090.1	Development and Implementation of Remote Monitoring Subsystems (RMS) within the National Airspace System (NAS)
FAA Order 6630.4	En Route Communications Installation Standards Handbook
FAA Order 6650.7	Airport Communications Media/Equipment Selection Criteria
FAA Order 6650.8	Airport Fiber Optic Design Guidelines
FAA Order 6950.2	Electrical Power Policy Implementation at NAS Facilities
FAA Order 6950.23	Cable Loop Systems at Airport Facilities
FAA Order 6950.26	Airport Selection Criteria for Power and Signal Distribution
FAA Order 6950.27	Short Circuit Analysis and Protective Device Coordination Study
BITSA	38EIG/ES (USAF) Base Information Transport System (Bits) Architecture

6.3.2 Non-Government Documents.

ANSI T1.105	SONET: Basic Description including Multiplex Structure, Rates, and Formats
ANSI T1.105.04	SONET: Data Communication Channel Protocol and Architectures
ANSI T1.105.06	SONET: Physical Layer Specifications
ANSI T1.105.09	SONET: Network Element Timing and Synchronization
ANSI T1.627	ATM Layer Functionality and Specification
EIA-STD-RS-359	Standard Colors for Color Identification and Coding
EIA-STD-RS-455	Standard Test Procedures for Fiber Optic Fibers, Cables, Transducers, Connecting, and Terminating Devices
IEEE 802.4	Token-Passing Bus Access Method and Physical Layer
IEEE 802.5	Token Ring Access Method and Physical Layer Specifications
ISO/IEC 8802-2	Information Processing Systems – Local Area Networks – Part 2: Logical Control
ISO/IEC 8802-3	Information Processing Systems – Local Area Networks – Part 3: Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer.
ISO/IEC 8802-4	Information Processing Systems – Local Area Networks – Part 4: Token-Passing Bus Access Method and Physical Layer Specification
ISO/IEC 8802-5	Information Processing Systems – Local Area Networks – Part 5: Token Ring Access Method and Physical Layer Specification
TIA/EIA-422	Electrical Characteristics of Balanced Voltage Digital Interface Circuits
TIA/EIA-530	High-Speed 25-Posistion Interface for Data Terminal Equipment (DTE) and Data Circuit-Terminating Equipment (DCE)

(END OF DOCUMENT)